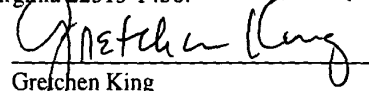


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APPLICATION FOR UNITED STATES LETTERS PATENT

FOR

LOCKING APPARATUS WITH PACKOFF CAPABILITY

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CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the priority of U.S. Provisional application serial number 60/413,037 filed September 24, 2002.

BACKGROUND OF THE INVENTION

5 FIELD OF THE INVENTION

[0002] The present invention relates to tools for developing and producing fluids from subterranean wells. More particularly, the invention is a wireline or coiled tube positioned locking apparatus for securing the position of a production tube flow control or measurement tool in a landing nipple located in a tubing string having a profile and seal bore specifically
10 prepared to accept the locking apparatus with packing.

DESCRIPTION OF RELATED ART

[0003] A prior art procedure for placing and securing a subterranean well tool at a predetermined position within a well production tube is a special purpose locking apparatus
15 having a collet or locking dogs that are mechanically actuated by surface manipulated wirelines or coiled tubing. Usually, the locking tool is attached to the top of the well tool or instrument and to a wireline running tool. The assembly is lowered into the well at the end of the wireline to the desired depth and location. Radially expandable locking dogs or collets are actuated, for example, by wireline manipulation to engage or mesh with cooperative surfaces, receptacles or
20 profiles within the tubing.

[0004] A common method of positioning a subterranean well tool within a well conduit, such as a tubing string, is to insert a locking apparatus in a landing nipple, the landing nipple being pre-installed at a particular location within the tubing string and containing a profile into which the locking apparatus may engage. The locking apparatus will normally no-go on a shoulder of

the landing nipple and will have means of locking into the profile of the landing nipple using outward expanding members such as dogs or collets.

[0005] Normally associated with the locking apparatus is a set of chevron packing rings to provide a seal between the landing nipple and a well tool attached to the locking apparatus, such as a blanking plug or safety valve. Typically, the packing is positioned in a polished seal bore of the landing nipple, between two fixed limiting shoulders on the locking apparatus and a well tool such as a blanking plug or safety valve. Unfortunately, however, it is not unusual for the seal bores of the landing nipple to be damaged in the well either by wireline cutting (longitudinal grooves) or by general corrosion. Prior art locking devices have not provided a mechanism or procedure to apply axial compressive loading of the packing to improve sealing by extrusion into such grooves pits or imperfections.

[0006] U.S. Patent No. 4,295,528, for example, is a patent for a "Selective Lock with Setting and Retrieving Tools." Element 104 in Fig. 2c of this '528 patent represents a chevron packing unit or assembly installed on the mandrel of the wireline lock in a typical manner. The purpose of the chevron packing is to provide a seal between the mandrel and the seal bore in a landing nipple. However, the chevron packing material is only confined between two fixed shoulders at each end of the packing and has no capacity for operational adjustment.

[0007] Similar fixed or static shoulder confinements for chevron seals are disclosed in U.S. Patents 4,315,544; 4,510,995; 4,583,591; and 4,823,872. U.S. Patents 4,406,324 and 4,993,493 also disclose oilfield equipment that employs chevron packing located between two fixed shoulders. The chevron packing is landed either on the lock mandrel or the tool attached to the lock mandrel and is always trapped between two fixed shoulders that position and confine the chevron packing rings but does not compress them.

[0008] Somewhat different in concept is the locking device described in U.S. Patent No. 5,348,087 which can actually have a seal bore larger than the internal diameter of the tubing string. The locking device contains an elastomeric packing element located on a mandrel. The mandrel contains an enlarged diameter portion which, when driven beneath the packing element, causes the packing element to expand radially and engage the seal bore of the nipple. Due to relative movement of the mandrel, the expanding metal rings on each side of the packing element can not be considered fixed until after the lock is set. After the lock is set, however, they essentially become fixed with respect to the packing element and there is no provision for applying or increasing the end load on the packing element of this device as a means for improving the sealing.

[0009] It is, therefore, an object of the present invention is to provide a locking apparatus having the ability to apply axial compressive loading on a chevron packing or other packing configuration associated with the locking apparatus.

[0010] Another object of the present invention is a means to improve the sealing ability of locking apparatus packing under adverse condition such as mechanical or chemical corrosion damage to seal the bore of the landing nipple or other adverse sealing condition such as high pressure and high temperature.

[0011] Also an object of the present invention to provide a locking apparatus having the ability to apply an axial compressive load to the chevron packing to improve sealing of the packing using conventional wireline manipulation means.

[0012] Another object of the present invention is locking apparatus mechanism having the capacity to apply an axial end load to the chevron seal packing thereby forcing the packing

material into grooves or other imperfection in the seal bore of the landing nipple to effect a seal when otherwise, the seals would leak.

[0013] Also an object of the invention is provision of an ability to apply an axial compressive load to locking apparatus chevron seals to aid in sealing the tubing bore under high pressure, high temperature applications, even when the seal bore in the landing nipple is perfect.

[0014] An additional object of the invention is to provide the means of applying additional axial compressive loading in a remedial action to shut off an existing leak using normal wireline manipulation means.

SUMMARY OF THE INVENTION

[0015] The invention provides an ability to apply a compressive, axial loading on the chevron packing to expand the packing material radially thereby forcing the chevron packing material into the grooves, pits or other imperfections in the seal bore of the landing nipple and thereby effecting a seal when otherwise, the seal would leak.

[0016] To these ends, the present well tool locking connector includes an interior packing mandrel having a first cylindrical surface that carries a compression expanded packing ring that is axially confined along the packing mandrel first surface by an compression abutment shoulder. An axial extension of the packing mandrel transitions over a ramped shoulder onto a second, lesser diameter cylindrical surface. At least a portion of the second cylindrical surface extended from the ramped shoulder is profiled with directionally biased channels such as buttress threads. A body lock ring having a correspondingly profiled I.D. meshes with the packing mandrel surface profile.

[0017] Further along the packing mandrel extension from the ramped shoulder and the meshed locking ring is a fishing tool connection surface such as a locking dog receptacle detent or channel or a fishing barb ring.

[0018] Between the fishing tool connection surface and the meshed locking ring, a control sleeve
5 slidably overlies the packing mandrel extension. The control sleeve also includes a fishing tool connection surface such as that used for the packing mandrel, preferably. Distal from the fishing tool connection, the control sleeve includes an abutment shoulder band having an O.D. shoulder in facing proximity with the fishing tool connection and an I.D. shoulder in facing proximity with the locking ring. The I.D. shoulder of the control sleeve is axially recessed from a retaining
10 ring abutment shoulder.

[0019] A locking dog caging sleeve slidably overlaps the first cylindrical surface of the packing mandrel and the control sleeve abutment shoulder band. An end of the caging sleeve lapped upon the first cylindrical surface of the packing mandrel proximate of the packing ring is a compression ram. An opposite distal end of the caging sleeve includes a I.D. abutment shoulder
15 in facing proximity with the O.D. abutment shoulder of the control sleeve. One or more locking dogs are confined by caging slots in the caging sleeve. A radially expandable retaining ring provides a preset connection between the body lock ring and the caging ring.

[0020] A preset alignment of the tool components is secured by calibrated shear fasteners. Such preset alignment provides a retracted position for the locking dog or dogs and an uncompressed
20 packing ring for well run-in. When suspended at the end of a suitable suspension structure such as a wireline or coiled tubing, for location within a well, the fishing tool engagement surfaces respective to the packing ring mandrel and the control sleeve are axially separated by a first manipulation of the suspension structure to translate the packing ring mandrel relative to the

caging sleeve and the control sleeve. This translation draws the ramped shoulder of the mandrel under or in radial contiguity with the locking dog thereby causing a radial displacement of the locking dog or dogs into a well tubing receptacle or detent channel. Simultaneously, the packing ring is compressed between the mandrel compression shoulder and the ram end of the caging sleeve. Such compression expands the sleeve radially to a pressure sealing engagement with the inside bore wall of the well tube.

[0021] When the packing mandrel is drawn against the control sleeve, the buttress threads are translated under the lock body ring to rectify the movement and secure the compressed position.

[0022] At this point, the tool connector is locked and sealed with the tubing bore. The suspension structure may be released from the fishing tool connection surfaces and withdrawn from the well for replacement by other tools, if desired.

[0023] When release of the well tool from the tubing is desired, fishing tools reengage the mandrel and control sleeve. A second manipulation of the suspension structure translates the control sleeve from abutted engagement of the respectively facing abutment surfaces. This translation of the control sleeve also extracts a spacing hood portion of the control sleeve from between the retaining ring and the caging sleeve thereby permitting it to expand out of linkage engagement between the lock ring and the caging sleeve. A third manipulation of suspension structure translates the first cylindrical surface of the mandrel from under the locking dog or dogs thereby permitting a radial retraction of the dog from the tubing channel. The same mandrel translation decompresses the packing ring.

BRIEF DESCRIPTION OF DRAWINGS

[0024] For a thorough understanding of the present invention, reference is made to the following detailed description of the preferred embodiments, taken in conjunction with the accompanying drawings in which like reference characters designate like or similar elements throughout the several figures of the drawing.

[0025] **Figure 1** is a sectioned view of a locking apparatus in operative assembly with a running tool set for well run-in.

[0026] **Figure 2** is a sectioned view of a locking apparatus in operative assembly with a running tool in an intermediate well setting condition.

10 [0027] **Figure 3** is a sectioned view of a locking apparatus in operative assembly with a running tool in a set and sealed condition within a well production tube.

[0028] **Figure 4** is a sectioned view of a locking apparatus in operative assembly with a running tool where the locking apparatus is in a set and sealed condition and the running tool is released from the locking apparatus.

15 [0029] **Figure 5** is an enlarged sectioned view of the locking apparatus configured for well run-in.

[0030] **Figure 6** is an enlarged sectioned view of the locking apparatus configured for a locked and sealed setting within a well production tube.

[0031] **Figure 7** is an enlarged sectioned view of the locking apparatus configured for release
20 from a well production tube.

[0032] **Figure 8** is an enlarged sectioned view of the packing seal portion of the locking apparatus.

[0033] **Figure 9** is an enlarged sectioned view of an alternative packing seal assembly.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0034] A first embodiment of the invention is represented by Fig. 1 to include a running tool 10 attached to a wireline lock 20. The running tool 10 comprises An inner mandrel 12 that may be a threaded assembly of several sections to provide a structurally continuous tube element that extends between a threaded box end 13 and a threaded pin end 14. Optionally, the pin end may also include a fishing neck 15. A running tool housing 30 is releasably secured to the mandrel 12 by a calibrated failure element such as a shear pin 32. The housing 30 is secured to the mandrel 12 at such a position as to provide translational space 62 between the sleeve end 35 and a mandrel abutment shoulder 64. The translational space 62 is covered by a housing extension sleeve 36. Opposite from the extension sleeve 36, the housing further includes a control dog housing 66. The control dog housing has a control dog detent channel 37 for cooperation with a control dog element 38. Additionally, the control dog housing provides a multiplicity of caging slots 41 for fishing neck dogs 40.

[0035] When free of the locking dog 38, the control dog housing 66 may slidably translate along a spring mandrel 16. A compression spring 17 is seated between the shoulder 68 on the control dog housing 66 and the spring seat shoulder 18 on the spring mandrel 16. The bias of spring 17 is to separate the respective spring seats and translate the spring mandrel end 70 into the space 72.

[0036] The outside perimeter of the inner mandrel 12 is profiled to provide a locking dog retraction channel 75 on one side of a locking dog support band 77 and a ramped shoulder 79 on the other side.

[0037] The inside perimeter of the spring mandrel 16 is profiled to provide a ramped shoulder 80 to cooperatively engage the ramped shoulder 79 on the inner mandrel 12. The outside perimeter of the spring mandrel 16 is also profiled with a ramped shoulder 82 for cooperative engagement with a corresponding inside shoulder ramp 90 near the end of the control dog housing 66.

5 [0038] Respective to Figs. 1 and 5, the primary structural element of the locking apparatus 20 is the packing mandrel 22 which includes the mandrel sleeve extension 25. The packing mandrel directly supports a chevron packing 28 against a compression shoulder 84. One or more shear pins 34 releasably secure the packing mandrel 22 to the running tool spring mandrel 16. Box threads 27 secure the locking apparatus to additional elements of the tool assembly that are to be
10 secured within the production tube. The inside perimeter of the packing mandrel sleeve extension 25 accommodates a fishing tool connection channel 44.

[0039] With respect to Fig. 5, the outer profile of the mandrel sleeve extension 25 is stepped to provide an elongated groove channel between an abrupt shoulder 86 and a ramped shoulder 88 on the packing mandrel 22. Between the shoulders 86 and 88, the outside surface of the ring
15 channel is grooved by, for example, buttress threads or rings 48. A lock ring 56 has corresponding buttress threads around its inside circumference to mesh with the threads 48. The lock ring 56 is an expansible hoop spring that will accommodate radial expansion to advance axially in one direction over the buttress threads 48 but opposes movement in the opposite axial direction.

20 [0040] A control sleeve 46 is slidably confined within the groove extension channel between the abrupt shoulder 86 and the lock ring 56. The end of the control sleeve proximate of the abrupt shoulder 86 has a threaded connection with a lock assembly sleeve 23 whereby both elements function dynamically as an integral structure.

[0041] The control sleeve 46 also includes a hood extension 49 that projects over the lock ring 56. The hood extension 49 includes a counterbored shoulder that confines a retainer ring 58 against an end shoulder of a locking dog cage 52. The retainer ring 58 is an expansible hoop spring that is biased to expand against the inside surface of the hood extension 49.

5 [0042] An extension 54 of the locking dog cage 52 laps over the control sleeve 46 and the hood extension 49. The distal end of the cage extension 54 is rimmed to provide an outside abutment face 55 and an inside abutment shoulder 57. The locking dog cage 52 laps onto the outside packer seal surface of the packer mandrel 22 to cover a translational space 59 between the ramped shoulder 88 of the of the mandrel 22 and the lock ring 56. Within the locking dog cage
10 52 are a plurality of locking dogs 50 that are confined by slots to radial movement into and out of the translational space 59. A corresponding translational space 96 is provided between the inside abutment shoulder 57 and a control sleeve shoulder 47. A calibrated failure fastener 60 such as a shear screw secures an initial axial relationship between the locking dog cage 52 and the control sleeve 46. A safety fastener 24 between the lock assembly sleeve 23 and the packing mandrel
15 sleeve 25 also provides alignment security during transport to the well location. The safety fastener 24 is removed, however, after the locking apparatus 20 is assembled to the running tool 10 but before it is inserted in the well.

[0043] Preparatory to well descent, the wireline lock tool 20 is assembled with the running tool 10 in the manner illustrated by Fig. 1. The inner mandrel 12 of the running tool is secured to the
20 sleeve 35 end of the housing 30 by the upper shear pin 32. An end thread on the mandrel 12 secures it to a tool joint pin 14 to facilitate connection of the assembly to a well suspension structure such as a wireline or coiled tubing.

[0044] The spring mandrel 16 is aligned along the inner mandrel 12 length to position the locking dog support band 77 under the control dog 38 thereby meshing the control dog 38 into the detent ring 37 in the control dog housing 66. This meshing of the control dog 38 in the housing 66 detent ring 37 immobilizes the spring mandrel 16 with the housing 30 and hence, due to the upper shear pin 32, with the inner mandrel 12.

[0045] The lower end of the running tool 10 penetrates the central bore of the locking apparatus 20 to receive the lower shear pin 34 through the spring mandrel 16. This calibrated shear failure assembly is supplemented by the meshed engagement of the fishing neck dog 40 with the detent channel 42 in the lock assembly sleeve 23. The meshed engagement of the fishing neck dog 40 is supported by the outside surface of the spring mandrel 16.

[0046] Before the assembly enters the wellhead, the safety fastener 24 is removed. The locking apparatus 20 remains mechanically linked to the running tool 10 by the fishing neck dog 40 and the lower shear pin 34.

[0047] Upon alignment with the desired downhole location, the assembly is “jarred” to shear the upper shear pin 32. That event allows the running tool housing 30 to translate along the inner mandrel 12 and close the translational space 62 as illustrated by Fig. 2. This axial downward shifting of the inner mandrel 12 with respect to the housing 30 also translates the control dog support land 77 downward out from underneath the control dogs 38 allowing the control dogs 38 to drop into the locking dog retraction channel 75. Alignment of the control dog 38 with the retraction channel 75 allows the control dog 38 to be radially displaced within the control dog cage of the spring mandrel 16 and out of the detent channel 37 in the control dog housing 66.

[0048] Retraction of the control dogs 38 from the control dog housing 66 releases the spring mandrel 16 relative to the housing 30 but does not release the spring mandrel from the packing

mandrel **22** of the locking apparatus **20** due to the lower shear pin **34**. Support linkage is also maintained by the fishing neck dog **40** engagement with the detent channel **42** in the lock assembly sleeve **23** and the abutment of shoulders **82** and **90** on the spring sleeve and control dog housing, respectively.

5 Furthermore, the control dog housing **66** is biased downward against the lock assembly sleeve **23** while the spring mandrel **16**, connected by lower shear pin **34** to the packing mandrel **22**, is biased upward, both due to the urging of the compression spring **17**. Consequently, when the control dogs **38** are released from the control dog housing **66**, the upward bias of the spring mandrel **16** lifts the packing mandrel **22** while holding the lock assembly sleeve **23** down thereby
10 causing a compressive closure between the packing mandrel **22** and the locking dog cage **52** shown by Fig 3. As the ramped shoulder **88** of the packing mandrel **22** engages with the locking dogs **50**, the locking dogs are radially displaced into a dog receptacle channel **102** in the landing nipple **100** component of the well fluid production tube thereby securing the locking apparatus **20** to the landing nipple **100** by a mechanical interference as is illustrated by **Figs. 3 and 4**.

15 **[0049]** Continued expansion of the spring **17** by compression of the packing ring **28** displaces the spring mandrel **16** relative to the control dog housing **66** until the support land **92** portion of the spring mandrel **16** passes from under the fishing neck dog **40**. As the ramped shoulder **82** passes the fishing neck dog **40** (Fig. 6), the dog **40** drops from the detent channel **42** thereby releasing the running tool **10** from the locking apparatus at that point. However, the shear pin
20 connection **34** between the spring mandrel **16** and the packing mandrel **22** remains.

[0050] With the locking apparatus thus secured to the landing nipple, additional upward jarring movement of the inner mandrel **12** as shown by **Fig. 4** causes the upward facing bevel at the lower end of the control dog retraction channel **75** to engage the inner bevel of the control dogs

38. With the inner mandrel 12 in physical abutment with the control dogs 38, such subsequent upward jarring shears the lower shear pin 34 to complete the release of the running tool 10 from the locking apparatus 20. Before the running tool release sequence is complete, however, the process imposes maximum compressive load against the chevron packing ring 28 between the ram end 53 of the locking dog cage 52 and the compression shoulder 84 of the mandrel 22. When compressed axially, the packing ring expands radially out to a pressure sealed engagement with the landing nipple I.D. 104. Upon shear failure of the pin 34, the running tool 10 is released from the locking apparatus 20 and may be removed from the well.

[0051] Also before the release sequence is complete, as the packing mandrel 22 is drawn against the relatively fixed position of the locking dogs 50 and cage 52, the sleeve 25 also advances the buttress threads 48 on the outer surface of the packing mandrel sleeve 25 under the lock ring 56. Fig. 6. As long as the retainer ring 58 remains engaged with the lock ring 56, displacement of the packing mandrel 22 relative to the locking dog cage 52 and control sleeve 46 is unidirectional. The buttress thread bias between the mandrel threads 48 and lock ring 56 prevents a reverse movement. Hence, the locking dogs 50 and packer seal 28 are secured at the engagement position with the landing nipple 100.

[0052] Displacement of the packing mandrel sleeve 25 relative to the control sleeve 46 also opens a translational space 87 shown by Fig. 6 between the abrupt shoulder 86 on the packing mandrel sleeve 25 and the stepped end of the control sleeve 46. This translational space 87 will come into use for eventual retrieval of the locking apparatus 20

[0053] Retrieval of the locking tool may be accomplished by a fishing tool not illustrated but of construction and operation as is well known to the prior art. In particular, such fishing tools have

two or more sets of axially translated fishing dogs carried by either a wireline or continuous tube workstring. Such fishing dogs are of common use in the industry.

[0054] Applied to the present invention, one set of such fishing dogs is manipulated to engage the outer detent channel 42 in the lock assembly sleeve 23. An inner fishing dog set engages the inner detent channel 44 in the packing mandrel sleeve 25. The lock assembly sleeve 23 has a threaded connection to the control sleeve 46 and when translated by force exerted by the outer fishing dog set on the outer detent channel 42, the screw 60 that links lock assembly sleeve 25 to the packing mandrel sleeve 25 fails and the control sleeve shoulder 47 is shifted against the inside abutment shoulder 57 on the end of the cage extension 54.

[0055] Translation of the control sleeve 46 withdraws the radial structure support of the hood extension 49 from the retainer ring 58 as shown by Fig. 7. Consequently, the retainer ring expands against the inside diameter of the cage extension 54. When expanded, the retainer ring 58 no longer links the locking dog cage 52 to the lock ring 56 and the packing mandrel sleeve 25. Hence, the packing mandrel sleeve 25 may be shifted by force applied with inner fishing dogs to the inner detent channel 44. This packing mandrel shift is oriented toward axial separation of the compression shoulder 84 from the ram end 53 of the locking dog cage 52. Hence, the seal surface 26 supporting the locking dogs 50 engagement with the landing nipple 100 is withdrawn and the locking dogs 50 are radially free to contract against the O.D. surface of the packing mandrel 22. Consequently, the locking apparatus 20 is released from mechanical interference engagement with the landing nipple 100 and may be withdrawn from the well.

[0056] Figure 8 is a close-up view, depicting in greater detail the packing sleeve 28 of the locking apparatus 20. As shown, the packing sleeve 28 includes a pair of metal end rings 110, 112 at either axial end, and a central metal ring 114. A stack of elastomeric chevron rings 116,

118 is disposed axially between each of the end rings 110, 112 and the central ring 114. Each of the chevron rings 116, 118 has a peaked, generally V-shaped cross-section that is apparent from Figure 8. When the ram end 53 compresses the packing sleeve 28, the chevron rings 116, 118 are flattened out such that the peaked V in their cross-section is substantially removed.

5 [0057] Figure 9 is an enlarged cross-sectional view of portions of locking device 20 incorporating an alternative axially compressible seal assembly 120 for use as packing sleeve 28. The compressible seal assembly 120 is known commercially as a "Dynamic Seal Assembly" available from Baker Hughes Incorporated. As the structure and function of this seal assembly is well known, it will not be described here. Other suitable seal assemblies may also be utilized as
10 or within the packing sleeve 28 in accordance with the present invention, including seal assemblies that incorporate, for instance, axially compressible hat rings and/or U-cups.

[0058] The preferred invention embodiment has been described to function with expanding dog fishing tools to engage the detent channels 42 and 44. Those of skill in the art will understand that external fishing connectors that accept and connect with overshot fishing tools may
15 obviously be substituted for the internal connectors 42 and 44.

[0059] Although the invention has been described in terms of particular embodiments which are set forth in detail, it should be understood that this is by illustration only and that the invention is not necessarily limited thereto. Alternative embodiments and operating techniques will become apparent to those of ordinary skill in the art in view of the present disclosure. Accordingly,
20 modifications of the invention are contemplated which may be made without departing from the spirit of the claimed invention.